Study on drying rate in contact drying with flexible screen

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Abstract The moisture contents (MC) of popular veneers were tested in Composition Board Laboratory of Northeast Forestry University by contact drying with flexible screen. The influence factors considered included temperature, initial moisture contents (IMC), and veneer thickness. Veneer-drying laws under different hot press conditions were analyzed. The results showed that the drying rate increased with temperature rising. 160℃ was considered to be more efficient than 140℃ and 180℃ because excessive high temperature has no significant contribution to drying rate. IMC had significant effect on drying rate. The veneer with high IMC had a higher drying rate at above fiber saturation point (FSP) and a lower drying rate at below FSP, compared to the veneer with low IMC. Average drying rate also varied with thickness in power law.

Key words: Drying rate, Contact drying, Flexible screen, Temperature, Initial moisture content, Veneer thickness

Introduction

A new type contact dryer with non-metal flexible platen was patented in 1998 in China, which special structure and material solved the problem of low productivity in platen drying. The machine was similar to hot press. Direct contact between wood and heated platen allows rapid heat transfer by conduction (Sandoe 1983). Though the flexible screen conducts heat slower than metal platen does, it transfers mass much faster. So water removing rate decides veneer-drying rate in the new machine. Water in veneers was removed out along the warp and weft of the special platen material. The non-metal flexible material formed a circle, loading and unloading was accomplished in the same time (Lu 1998).

In contact dryer, drying rate decided not only drying time and productivity but also the length of opening time and open times. In the process of drying, drying rate could be used to calculate moisture content (MC), consequently operator may adjust pressure or open platens. In order to discover the regulatory of drying rate in contact drying with flexible non-metal screen, some experiments have been conducted and analyzed in detail.

Raw material and drying conditions

Five hundreds popular veneers were cut into 350 ×350 mm in size and dried at 0.3Mpa pressure. They ranged in thickness from 1.5mm to 4.5mm and from 55% to 145% in initial moisture content (IMC). Test was conducted at 140℃, 160℃and 180℃.

A non-metal synthetic material was used as platen, called screen, with ventilation of 700m^3/m^2, opening ratio ≤10%, warp of 0.5 mm, and weft of 0.5 mm. Other satisfying properties include flexibility, tensile strength, long serve life and resistance to erosion and high temperature.

Effect of temperature on drying rate

Temperature was the most important factor influencing contact drying (Lu 1993). All the index regression graphs of three temperatures were similar. The higher the temperature was, the sooner the moisture content (MC) decreased. Average drying rate was shown in Table 1 when 1.85mm thickness veneers were dried from the same IMC to 7~8% at three temperature.

Table 1. Average drying rate at different temperature

IMC (%)	Temperature(℃)	Drying rate (%/s)
105	140	1.00
	160	1.15
	180	1.23
115	140	0.93
	160	1.06
	180	1.11
125	140	0.90
	160	0.99
	180	1.02

It was reflected in Table 1 that drying rate was improved with elevating temperature. From 140℃ to 160℃, drying rate rose largely, while from 160℃ to

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180℃, improved range was small. Furthermore, the former improvement was 2 times the later. High temperature provided fast drying rate and fast drying rate shortened drying time. Productivity was improved accordingly. For example, the veneers with 105%~125% MC needed drying time 147~178 s at 140℃. when heated to 160℃, drying time came down to 100~124 s, shortening 50 s or so. When heated to 180℃, drying time dropped to 75~91 s, decreasing 25 s. Both temperatures were elevated 20 s, from 140℃ to 160℃ and from 160℃ to 180℃, but the former saved double drying time of the later. Expression in graph would be that the graph of 160 ℃ was closer to that of 180℃ than to 140℃. 160℃ was considered to be suitable for production.

Effect of thickness on drying rate

Veneer thickness is an important factor to study. Cutting check became severer with increased thickness. Some veneer is nearly equal to thin board in thickness and difficult to dry. In convection drying, veneers with large size are prone to deform because of unsymmetry in structure, which aggravate breakage in turn. Degradation wastes precious wood resource. Whereas, mild drying conditions prolong drying time, and consequently reduce productivity.

Contact drying was a desirable method for thick veneers to correct deformation and limit breakage (Hua 1994). Veneers with different thickness were dried to 8% MC and varied drying rate was listed in Table 2. Veneer's MC varied with drying time in index law.

Table 2. Average drying rate of veneer varying with thickness (%/s)

Thickness	Initial moisture content (IMC) (%)				
(mm)	115	125	135	145	155
1.5	1.25	1.41	1.4		
2.1	0.75	0.73	0.8	0.83	0.85
2.7	0.51	0.53	0.55	0.56	0.59
3.25		0.43	0.43	0.45	
3.8		0.37	0.37		
4.5	0.28	0.27			

Veneer thickness exerted an obvious effect on contact drying in power law. The thicker the veneer was, the lower the average drying rate was. It was observed in operation that the time when vapor start gushing out began from 6.5s, 8~9 s, 13 s, 15~16 s, 20 s, 22~23 s after press closed, corresponding the veneer of 1.5, 2.1, 2.7, 3.25, 3.8 and 4.5 mm respectively. This meant preheating stage was prolonged due to increased thickness. When the veneer's thickness was less than 3mm,drying rate changed distinctly. Rather, drying rate declined rapidly with decreased thickness. When thickness was over 3mm,drying rate fell slowly. There were two main reasons for drying rate dropping. One was that the path for conducting heat into and mass out of veneer was longer in thick veneer than in thin veneer, consequently, veneer cost long time to heat inner water to boiling point and to exhaust. Another was that there was more water to be vaporized in thick veneer, which caused temperature dropping, and low temperature had a negative effect on drying rate, e.g. causing drying rate declined. It always took some time to reheat veneer up to required temperature.

Effect of IMC on drying rate

In this part, 1.85mm veneers were tested at 160℃. When veneers began to gush out vapor, the time was posted with veneers' IMC rising, which meant preheating stage was prolonged. Drying rate fluctuation caused by IMC was listed in Table 3.

Table 3. Average Drying Rate under Different IMC

Average IMC (%)	Drying rate above FSP (%/s)	Drying rate bellow FSP (%/s)
65	1.32	0.57
75	1.47	0.49
85	1.23	0.48
95	1.43	0.44
105	1.53	0.44
115	1.61	0.44
125	1.59	0.41
135	1.56	0.39
145	1.72	0.41

Table 2 gave such a conclusion that average drying rate rose with increased IMC. But the same regulation didn't remain in the whole drying process. Table3 showed drying rate changed in adverse trend between above FSP and below FSP. When the veneer with high IMC was dried, its drying rate was faster above FSP but slower below FSP than that of the veneer with low IMC. From different IMC to FSP, though drying rate rose, the higher the IMC was, the more water there was to be dried out. So the longer drying time was needed. However, from FSP to the same final moisture content (FMC), average drying rate was not equal as expected.

Below FSP, drying rate was still related to IMC. When dried to FSP, veneer with high IMC had stayed in wet and heat state for a longer period than veneer with low IMC. Pressure caused thickness loss (Wellons 1983) and increasing density prevented water from removing. In addition, energy compensation also needed time. Because of vaporizing free water above FSP heat was lost and caused platen's tem-

perature dropping. After FSP hot platen must spend some time to replenish temperature. Slow drying rate accompanied low temperature. So, veneer with high IMC had a slow drying rate below FSP and cost a long time to achieve the same FMC.

Summary

Three factors were considered in the experiment. The effect of temperature was distinct. The drying rate was accelerated and the drying time was shortened when temperature rose. From 140℃ to 160℃, there was a marketable variation in drying rate and drying time. However heated from 160℃ to 180℃, the effect was not as notable as former. Considering productivity and energy, 160℃ was appropriate.

IMC also affected contact drying. The higher the IMC was, the longer the drying time needed. When veneers with different IMC were dried to the same FMC, its drying rate at that point was not same. Regression graphs couldn't coincide even after moving parallel. So the drying time of veneers with low IMC couldn't be concluded simply by virtue of part graph used for veneer with high IMC.

Thickness of veneer exerted an obvious effect on drying rate in power law. The thicker the veneer was, the lower the average drying rate was, and within 3mm the rate changed largely.

The basic laws of drying rate had been analyzed. That was the preparation for study on hot platen opening in contact drying. What mentioned above laid a foundation for contact dryer designing and production.

References

Hua Yukun. 1994. Processing properties in Italian popular plywood production. Forestry Products Industry, **21**(4): 25~27

Lu Renshu. 1993. Plywood manufacture. Beijing: China Forestry Publishing House, 58pp

Lu Renshu, Hua Jun. 1998. Contact drying method with flexible screen. ZL application number: 98121006.6

Sandoe, M.D. 1983. Gluability of platen-dried veneer of Douglas fir. Forest Products Journal, **33**(7/8): 57~62

Welions J.D. 1983. Thickness loss in hot pressed plywood. Forestry Products Journal, **33**(1): 27~34